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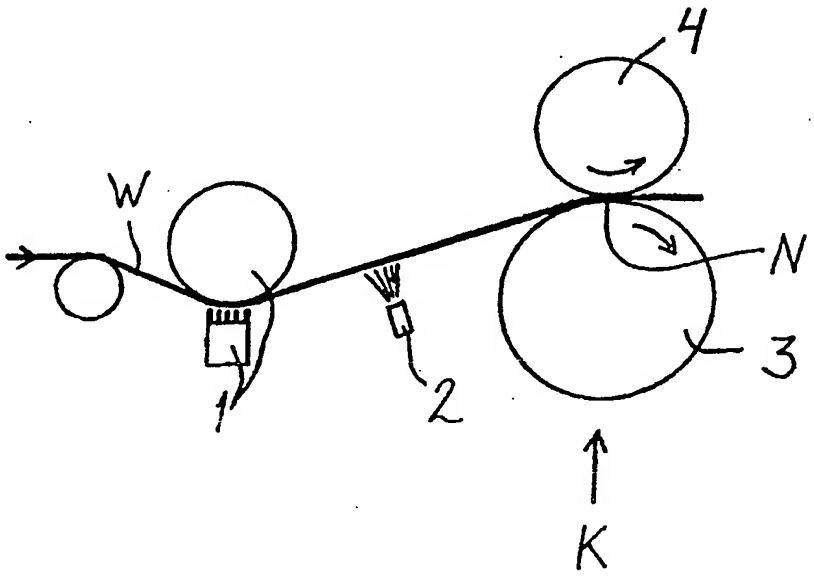
(54) Title: METHOD AND APPARATUS FOR TREATING THE SURFACE OF A WEB

(57) Abstract

In the method for treating the surface of the web, liquid is added on the surface of a paper or paperboard web (W), possibly with other constituents. The absorbency of the surface of the paper or paperboard web is increased before liquid is brought on the surface of the web or simultaneously with bringing the liquid on the surface of the web. The method is used for wetting the surface of the web before calendering, or for coating the web in surface sizing or pigmenting. The absorbency of the surface is increased before bringing the liquid for example by means of a corona treatment, a flame treatment, an ozonization or by adding steam.



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# Method and apparatus for treating the surface of a web

The invention relates to a method for treating the surface of a web, in which method liquid is added on the surface of a paper or paperboard web, possibly with other constituents. The invention also relates to an apparatus for implementing the aforementioned method.

The invention relates to the manufacture and finishing of paper, the end product of which is a finished paper. In particular, the invention relates to the manufacture of printing papers, intented to be printed at a separate stage after their surface has been finished and the web has been reeled.

After the paper or paperboard has been dried, the surface structure of the web is made suitable by means of a mechanical treatment, calendering. There are several calendering methods, but it is common to all of them that the web is passed through one or several nips which are formed between two surfaces, typically between rotating roll surfaces. The purpose of the calendering is to improve the paper quality by pressing the paper into a fixed final thickness, and especially by smoothing its surface. As is well known, the mouldability of the fibres contained in the paper or paperboard, the "plasticization" of the web in connection with the calendering, can be improved by increasing the temperature and/or moisture. It is often advantageous to restrict the impact of the temperature and moisture only on either surface layer or on both surface layers of the web, wherein the mouldability of their fibres can be improved without affecting the central layer of the web excessively. As a result of this, a known procedure is the wetting of the surfaces of paper or paperboard webs before the calendering of the web.

When wetting is utilized, the problem is that it is difficult to increase the water content to attain the desired moisture gradient in the thickness direction of the web. When for example steam is used, water can condensate poorly on the surface of the web, especially when its surface temperature is high. The most common problem is the hydrophobicity of the web, i.e. when the web is wetted by means of a

known method, the adhesion of the web to the surface is poor. To attain a sufficient wetting on the surface of the web, it is thus necessary to use such a dosage which results in an undesirable increase in the moisture also in the inner parts of the web. The aim is, however, to attain a steep moisture gradient between the surface and the inner part of the web. Hydrophobicity may result from the raw materials used in the pulp, but there is also an apparent hydrophobicity which results from the air film carried by the rapidly moving web, and the air brought along by the wetting liquid, which is perceivable especially in spray wetting.

Another problem occurring in the finishing of the web is the absorption of the composition used in surface sizing or pigmenting into the paper or paperboard web. Since the solutions, sizes and pastes used in these working stages are aqueous, the problems are based on the same facts as in the wetting.

The purpose of the invention is to eliminate the aforementioned drawbacks and to present a versatile method by means of which it is possible to attain a sufficient absorption of liquids, especially water, on the paper or paperboard web. To attain this purpose, the method according to the invention is primarily characterized in that the absorbency of the surface of the paper or paperboard web is increased before liquid is brought on the surface of the web or simultaneously with bringing liquid on the surface of the web. The absorbency of the surface can be improved e.g. by means of a preceding energy treatment, with which polar groups are produced in the material constituting the surface of the web, by means of a preceding addition of steam or an underpressure effecting simultaneously through the surface of the web.

Papers and paperboards are materials with heterogeneous surface energy. It has been discovered that the increase in the proportion of mechanical pulp and/or the act of adding a hydrophobic chemical increases the amount of fluctuation in the surface energy. The surface energy of the paper affects the absorbtion of liquids, the wettability of the surface and the adhesion properties of the surface. The more

uniform the structure in view of its surface energy is, the more uniform are the effects of said processes. By means of the above-described treatments it is possible to reduce and equalize the surface energy.

Especially when water is sprayed from underneath the paper with determined spraying parameters, the surface energy unequivocally determines the amount of water attached on the surface of the paper. The fluctuations in the surface energy appear in an irregular, small-scale fluctuation in the "adhesion" and moisture profile. This can cause an uneven calendering result, which causes e.g. mottling in printing. An uneven wetting of the surface results in that the sections which have a lower surface energy become wet and absorb water faster than sections with a higher surface energy. In practice, this can, in addition to the aforementioned reasons, result from irregularities in the moisture profile of the paper before wetting.

With the oxygen and radical reactions produced by means of an energy treatment, chemical changes are effected in the surface of the web W in the form of new polar groups, such as carbonyl, amide, hydroxyl and nitro groups, in the polymer material of the fibrous raw material of the web, especially in cellulose, hemicellulose and lignin. Thereafter it is easier to add the liquid, i.e. to perform the wetting with water, the surface sizing or the pigmenting.

The energy effecting the aforementioned chemical changes can be produced by means of a corona treatment, a flame treatment, an ozone treatment or a combination of these.

Another way of reducing the surface energy is to add steam. Steam can be brought in the form of hot or cold steam, and by means of a suitable dosage it is possible to attain a nearly monomolecular liquid layer. The steam is adsorbed evenly on the surface of the web, and it equalizes and maximizes the adhesion of a considerably larger amount of liquid brought at the next stage on the web.

The third way is to remove the apparent hydrophobicity of the web by means of an underpressure acting on the surface simultaneously with

the addition of liquid, the underpressure being effected through the web from the other side. To increase the absorbency of the surface in this way, it is possible to use a suction box and/or means producing at least underpressure impulses.

Furthermore, the purpose of the invention is to present an apparatus by means of which it is possible to produce a better adhesion of the liquid on the web. To attain this purpose, the apparatus is characterized in that in addition to the device for adding the liquid it comprises a device for reducing the hydrophobicity. This device is provided for bringing energy at least to the immediate vicinity of the surface of the web, to produce new polar groups on the surface of the web, for applying steam on the surface of the web, or for exerting direct underpressure on the surface of the web.

In the following, the invention will be described in more detail with reference to the appended drawings, in which

Fig. 1 shows the principle of the method according to the invention,

Fig. 2 shows a side-view of an apparatus according to the first embodiment of the invention,

Fig. 3 illustrates an experiment performed by means of the first embodiment of the invention,

Fig. 4 shows a side-view of an apparatus according to the second embodiment of the invention, and

Fig. 5 shows a side-view of an apparatus according to the third embodiment of the invention.

Fig. 1 illustrates the treatment stages of a paper or paperboard web W according to the invention. The web in question travels in a paper or paperboard machine or in a finishing machine for paper or paperboard, and its surface is subjected to finishing whereafter it is reeled to form a

reel. Hydrophobicity is reduced at a stage A by means of a treatment effected on the surface of the web on the same side from which liquid is added at a stage B. It is also possible to reduce the hydrophobicity at a stage C by means of a treatment effected from the opposite side of the web W on the surface of the web on which liquid is added. This treatment stage C can take place simultaneously with the stage B or slightly thereafter. Finally, the web W is passed to a finishing stage D of the surface which can follow immediately after the stages A and B or after the stages B and C.

The need to reduce the hydrophobicity arises after a press at that stage when a completely formed web is at least partly dry, and it is absorbent for re-wetting. When the hydrophobicity occurs for the first time, the dry matter content is approximately 60 to 65%.

The liquid to be added denotes liquid as such or liquid in a formulation in which other substances are mixed therein, for example substances used in surface sizing and pigmenting, wherein the liquid functions as a carrier for these substances. In these cases the liquid is issued in the form of a surface sizing solution, a surface sizing paste, or a coating colour. The liquid is any liquid whose adhesion to the web can be improved by reducing the hydrophobicity on the surface of the web, especially water. The above-described stage B can thus be wetting, surface sizing or pigmenting.

In the paper machine or finishing apparatus for paper, the treatment is effected on the web W which moves at a high speed past the treatment sections. After the stages A and B or B and C the finishing effected on the web at the stage D can be immediately succeeding calendering, if the stage B is wetting, or it can be drying and calendering, if the preceding stage B is surface sizing or pigmenting.

Fig. 2 schematically shows the paper or paperboard web issued from a drying section in a paper or paperboard machine, which web W is passed to a calender K. Before the calender in the travel direction of the web, there is a device 1 for applying energy, by means of which device 1 energy is issued into the layer of air bordered by the surface of

the web travelling past the device, the energy also affecting the surface of the web in such a way that more hydrophilic groups are produced. In the travel direction of the web W, the device is succeeded by a wetting apparatus 2 by means of which the surface whose hydrophilicity was increased at the previous stage, is wetted. Thereafter the web W is passed to the calender K, which in the drawing is illustrated by two rolls 3 and 4 between which there is a calender nip N through which the web is passed. The nip in question can be the only nip in the calender, or there may be several successive calender nips in the travel direction of the web, wherein the drawing shows the first one of them. The calender is not restricted to any type, and it can be a machine calender, a soft calender, a long-nip calender or a multiple-roll calender.

The device 1 applying energy on the web can be a corona treatment device, which is provided with an electrode or a series of electrodes, located at a distance of a small air gap from the surface of the web W, and on the opposite side of the web with a counter-electrode, e.g. a roll. The corona treatment is based on the fact that the air gap between the electrode and the paper or paperboard web has a lower dielectric discharge voltage than the web itself. When a high frequency high voltage is produced between the electrode and the counter electrode, the air between the electrode and the web is ionized, and generates a gaseous conductor which can be seen as a blue corona. The corona burst generated with the electrode produces the following oxidants: ozone, atomic oxygen, free oxygen radicals and high-speed electrons, whose energy in the corona burst often reaches the amount of several keV, e.g. the value of approximately 10 keV. The energy is sufficient for breaking the bonds present on the surfaces of the fibres and between the fibres. When the bonds break, very reactive free radicals are produced on the surface of the web, which free radicals react with the oxidants produced in the corona treatment. The surface of the web becomes oxidized, and new polar groups are produced in the polymer material of the fibres on the surface, the polar groups being primarily carbonyl, amide, hydroxyl and nitro groups. These groups provide new adsorption sites for water, thus increasing the hydrophilicity of the surface.

In addition to the aforementioned chemical effect the corona treatment also has an electrical effect which improves adhesion, because the corona burst charges the surface of the web.

Alternatively, the device 1 directing energy can be a flame treatment device. In the flame treatment, the act of subjecting the surface of a paper or paperboard web W to an oxidizing flame with high thermal energy produces reactions similar to those described above on the surface of the paper or paperboard web, as well as an increase in the hydrophilicity via these oxidizing reactions. A further advantage of the flame treatment is that it improves the coatability of the web by removing so-called "standing" fibres from the surface of the web.

In the corona burst ozone is also produced, which has an effect on the surface of the web. The surface of the web can also be subjected to an oxidizing effect by means of a special ozone treatment, ozonization, in which a suitable amount of ozone is directed as such to the web from an ozone generator. The device 1 can thus be an ozonizer, by means of which energy is issued on the surface of the web in the form of chemical energy contained in gas. In this context it is also possible to use the term energy treatment device.

Furthermore, it is possible to place e.g. two different devices such as a corona treatment device and a flame treatment device, a flame treatment device and an ozonizer, or an ozonizer and a corona treatment device successively before the wetting apparatus 2 on the same side of the web. With the combined effect of these treatments it is possible to attain a strong oxidizing treatment. These different treatments can take place in either order. Furthermore, the invention does not exclude the possibility that all the three treatments take place succesively in a suitable order.

The aforementioned treatment is effected on the surface of the web on which the fibres are exposed. It is also possible, that the web W has already been surface sized before it is passed to the aforementioned energy treatment and wetting. Thus, the treatment has the same effects as on the bare surface of the web. In the starch, modified starch, other

natural polymers or their derivatives or in corresponding substances, such as synthetic polymers; used in the surface sizing, polar groups are produced analogously with the phenomena occurring in the cellulose, hemicellulose or lignin.

The aforementioned energy treatments are described for example in an article by S. Greig "Adhesion promoters for extrusion coating & cast film - a three-pronged attack", in a conference publication "Extrusion coating of paper and paperboard", 1990 and in the book by Chi-Ming Chan: "Polymer Surface Modification and Characterization", pp. 265—279. These publications primarily discuss the increase of adhesion of plastic coatings in extrusion coating.

The aforementioned treatments or a combination of them can be performed either on one side or on both sides of the web W. Thus, there are many alternatives that are possible before wetting, namely:

- The corona treatment only on one side, the opposite side untreated,
- the corona treatment on both sides,
- the flame treatment only on one side, the opposite side untreated,
- the flame treatment on both sides,
- the ozonization only on one side, the opposite side untreated,
- the ozonization on both sides,
- the corona treatment on one side and the flame treatment on the opposite side,
- the corona treatment on one side and the ozonization on the opposite side,
- the ozonization on one side and the flame treatment on the opposite side,
- a combination of the corona treatment and the flame treatment only on one side, the opposite side untreated,
- a combination of the corona treatment and the ozonization only on one side, the opposite side untreated,
- a combination of the ozonization and the flame treatment only on one side, the opposite side untreated,

- a combination of the corona treatment and the flame treatment on one side, only the corona treatment on the opposite side,
- a combination of the corona treatment and the ozonization only on one side, only the corona treatment on the opposite side,
- a combination of the ozonization and the flame treatment only on one side, only the corona treatment on the opposite side,
- a combination of the corona treatment and the flame treatment only on one side, only the flame treatment on the opposite side,
- a combination of the corona treatment and the ozonization on one side, only the flame treatment on the opposite side,
- a combination of the ozonization and the flame treatment on one side, only the flame treatment on the opposite side,
- a combination of the corona treatment and the flame treatment on one side, only the ozonization treatment on the opposite side,
- a combination of the corona treatment and the ozonization treatment on one side, only the ozonization treatment on the opposite side,
- a combination of the ozonization and the flame treatment on one side, only the ozonization treatment on the opposite side
- a combination of the corona treatment and the flame treatment on both sides,
- a combination of the corona treatment and the ozonization on both sides,
- a combination of the ozonization and the flame treatment on both sides
- a combination of the corona treatment and the flame treatment on one side, a combination of the corona treatment and the ozonization on the opposite side,
- a combination of the corona treatment and the ozonization on one side, a combination of the ozonization and the flame treatment on the opposite side,
- a combination of the ozonization and the flame treatment on one side, a combination of the corona treatment and the flame treatment on the opposite side.

The alternatives which entail a combination of two different types of treatments on the same side can also contain a treatment of a third type on the same side.

Naturally, the wetting is effected on that side of the web W which has been subjected to a treatment of adding hydrophilic groups in any of the aforementioned ways. If the treatment has been conducted on both sides of the web W, the wetting by means of the wetting device 2 is effected on both sides of the web, and this two-sided wetting treatment is illustrated with a second wetting apparatus depicted with broken lines in the drawing. The wetting device can function on any of the following principles:

- spray wetting
- film transfer wetting (LAS, sym-sizer, etc.)
- moistening by adjusting the relative humidity of air
- steaming

As a result of the treatment conducted before wetting, the contact angle of water on the surface of the paper is considerably reduced, i.e. the surface energy is reduced.

The corona, flame and ozonization treatments are the advantageous alternatives for treating the surface of the web, because they are efficient enough for producing changes in the structure of the surface of the web. There are also other treatment alternatives which will be discussed hereinbelow.

One possible pretreatment method is the production of a surface charge on the surface of the web on the side which is wetted at a later stage.

The pretreatment according to the invention is helpful especially in spray wetting underneath the web, in which the surface energy is the determining factor in the adhesion of the liquid on the paper. According to the preferred embodiment, the treatment is conducted at least underneath the web for a bottom-side spray wetting.

Similarly, the treatment also makes it possible to increase the amount of water that can be added e.g. by means of steaming in the web.

Naturally, in the two-sided wetting it is possible to utilize different wetting principles on different sides of the web.

In the wetting the web obtains the desired surface moisture, and it is passed in this moisture into the calender nip N of the calender K.

The wetting can also be replaced by adding liquid as a carrier material contained in the composition to be applied on the surface of the paper web, such as the surface sizing of the paper web or the pigmenting of the surface. Thanks to the pretreatment, the aqueous compositions added at these working stages adhere better on the web.

The pretreatment is especially well suited for coating methods in which the composition is brought in contact with the web at a low pressure: spray coating, jet coating as well as spreading roll application.

Fig. 3 shows water sorption as a function of the contact time for fully sized fine paper with different powers in the corona treatment, and for unsized and soft sized fine paper. The size used in the surface sizing is AKD glue. The fully sized sample, whose comparative test effected without a treatment is also shown, was subjected to the corona treatment using three different powers. The reference samples were an unsized fine paper and a fine paper soft surface sized with AKD, which were not subjected to the treatment.

Fig. 3 shows that the corona treatment clearly increases the water sorption of the surface sized paper, and the sorption is proportional to the power used.

Fig. 4 shows a second alternative in which the hydrophobicity of the surface is reduced by subjecting the surface to a steam treatment. The treatment device 1 can be a suitable device, such as a steam box, which doses steam on the surface of the web. The steam can be

applied in the form of hot or cold steam, and it adsorbs evenly on the surface. The steam can be dosed in such a small quantity, that nearly a monomolecular liquid layer is obtained on the surface. Such quantities do not substantially increase the moisture content of the paper, and they can be applied e.g. in the form of hot steam on a hot web.

As a result of the treatment, the contact angle of the water on the surface of the paper is reduced uniformly into zero. This equalizes and maximizes the adhesion on the web of a considerably larger quantity of liquid (e.g. "bulk water"), which is introduced at the next stage.

By means of steaming it is possible to apply the maximum quantity of $2g/m^3$ of water on such a cold paper web whose surface has not been pretreated to increase the adsorbtion of steam.

The steam treatment is especially advantageous in spray wetting from underneath the web, because in this wetting method the surface energy has a great significance in the adhesion of the liquid on the surface of the paper web. Thus, Fig. 4 illustrates the treatment device 1 underneath the paper web W, and a spray wetting device 2 located thereafter in the travel direction of the web. The invention is not, however, restricted to this arrangement, but corresponding devices may also be located successively above the paper web W. It is also possible that the aforementioned successive treatments are conducted both on the upper and the lower side.

After the wetting the web is guided substantially in the same surface moisture in the calender nip of the calender.

The wetting may be replaced with any of the aforementioned treatment methods in which the liquid functions as a carrier material in the composition to be added on the surface.

Fig. 5 shows a third embodiment according to the invention. Here, the wetting in question is a spray wetting below the web W by means of a wetting device 2. The web W which is moving at high speed carries along an air film whose thickness is proportional to the driving speed

and the roughness of the paper. This air film is ilustrated schematically with an arrow I1. When liquid is sprayed on the surface of the paper by means of dispersing air spray nozzles according to Fig. 5, the dispersing air is typically in the order of 4 bar and the pressure of the liquid is usually between 0.5 and 2 bar. Thus, the dispersing air accompanying the spray fills the pores P of the paper with air. In the appended drawing, in which the size of the pores is exaggerated for the sake of clarity, this air is marked with the reference I2.

The dispersing air accompanying the spray and the air carried along by the web W impair the adhesion of the liquid on the web, because the dispersing air entering the pores decelerates the absorption of liquid in the paper and the air film already initially impairs the contact of the liquid and the web.

To reduce the apparent hydrophobicity resulting from the aforementioned phenomenon and not from the surface structure or materials of the web, a treatment device 1 is placed on the opposite side of the web, in the case of Fig. 5 above the web, which treatment device is substantially across the entire width of the web in contact with the surface of the web W or with the surface of a highly air-permeable supporting belt loop, such as a wire 5, supporting the web at this point, and it produces at least an underpressure through the web on the surface which is subjected to the wetting. This device improves the physical adhesion of the liquid and the web by sucking air through the web W away from the path of the water front. The underpressure can be produced by suction boxes with a known structure, which suction boxes are previously known only in connection with the wet end of the paper machine, in which they suck the water contained in the web away from the web at a large water content. The device shown in Fig. 5 in more detail comprises at least one stationary member 1a extending in the transverse direction of the web substantially over the entire width of the web. The member produces at least an underpressure impulse with a co-operative action of its shape and/or position and the rapid movement of the web. The member is a foil known from the wet end, and there are advantageously two or more of them successively in the travel direction of the web. These foils produce the underpressure in

the form of underpressure impulses. They also produce the over-pressure impulses which precede the underpressure impulses, and which are shown schematically by vacuum profiles placed in corresponding locations in the upper part of Fig. 5, in which the X-axis corresponds to normal pressure.

The foil/s may be placed as such against the surface of the web, or they can be placed as a covering structure of a suction box. The suction box and the change it produces in the vacuum profiles is illustrated in Fig. 5 with broken lines.

Naturally, such a placement is also possible that the suction box, foil/s or both are located below the web, and the spray wetting is effected from above.

After the wetting the web is guided substantially in the same surface moisture in the calender nip of the calender.

When a web which has been surface wetted in any of the above-described manners is calendered, it is possible to use many known solutions as the calender K. The calender nip N shown in the drawings can be a hard nip, a soft nip, or a long nip which has been produced with a belt or a shoe. The aforementioned nip variations can be implemented by means of two hard rolls, two soft rolls, a soft and a hard roll, a roll and a belt, and a roll and a shoe. The calender can also be provided with several successive nips, of which two or more successive nips can be of the same type or of a different type. Similarly, it is possible that the calender is a multiple-roll calender in which successive nips are formed between the rolls in a stack of rolls.

The calendering advantageously entails the heating of the surface of the web by means of a heated, smooth calender surface in the calender nip N. It is also possible that heating and smoothing is effected in the calender only on the upper side of the web, only on the lower side of the web or on both sides of the web. Naturally, the aforementioned treatment is effected at least on that side whose hydrophilicity has been

initially increased in a way described above, and which has been wetted thereafter.

The invention is not restricted solely to the aforementioned treatment points in the travel path of the paper or paperboard web, but it can be used in all points after the occurrence of hydrophobicity. According to the invention, the reduction in hydrophobicity can also be conducted in the drying section, in which the web is later rewetted e.g. between drying groups to adjust the moisture profile. It is a known procedure to re-wet the web in the drying section by controlling the wetting in the transverse direction of the web from the wetting devices. According to the invention, the wetting can be profiled by adjusting the pretreatment reducing the hydrophobicity in the cross machine direction. The effect of the device producing the corona treatment and/or flame treatment and/or ozonization treatment is thus adjustable in different points in the cross machine direction, or there may be separate devices adjustable independently of each other in the cross machine direction. Thus, certain portions of the web can be rendered sensitive to absorb more water than others. Thus, the wetting need not necessarily be profiled separately, i.e. the wetting device can be "evenly" spreading. The aforementioned profiling possibilities naturally exist in the wetting effected before calendering as well. The profiling is advantageous especially in spray wetting, especially in sparay wetting underneath the web, and in the wetting effected by means of steaming.

The method and the device can be used in connection with a coating station and/or on-line calender functioning as a direct extension to the process of making paper or paperboard, or in a separate working stage when temporarily stored paper or paperboard is coated and/or calendered, the surface of such paper or paperboard being already initially dry for re-wetting.

Claims:

1. Method for treating the surface of the web, in which method liquid is added on the surface of already formed, at least partly dried paper or paperboard web (W), possibly with other constituents, **characterized** in that the absorbency of the at least partly dried surface of the paper or paperboard web is increased before liquid is brought on the surface of the web, or simultaneously with bringing the liquid on the surface of the web.

2. Method accordig to claim 1, **characterized** in that the absorbency of the surface is increased by means of an energy treatment, with which new polar groups are produced on the material constituting the surface of the web, whereafter liquid is added on the surface treated in this way.

3. Method according to claim 2, **characterized** in that the surface of the web (W) is subjected to a corona treatment.

4. Method according to claim 2, **characterized** in that the surface of the web (W) is subjected to a flame treatment.

5. Method according to claim 2, **characterized** in that the surface of the web (W) is subjected to an ozonization.

6. Method according to any of the claims 2 to 5, **characterized** in that the surface of the web is subjected to at least two different types of treatments selected from the group consisting of corona treatment, flame treatment and ozonization.

7. Method according to claim 1, **characterized** in that the absorbency of the surface of the web is increased by adding steam, whereafter liquid is added on the surface treated in this way.

8. Method according to any of the claims 2 to 7, **characterized** in that the liquid is added to the surface of the web to wet the web, whereafter the web is calendered.

9. Method according to any of the claims 2 to 8, **characterized** in that the liquid is added on the surface of the web in a spray wetting underneath the web.

10. Method according to any of the claims 2 to 7, **characterized** in that the liquid is added on the surface of the web along with other constituents intended as a coating of the web.

11. Method according to claim 1, **characterized** in that the absorbency of the surface is increased by means of an underpressure affecting the surface, which underpressure is effected through the web (W) from the other side simultaneously with adding liquid on the surface.

12. Method according to claim 11, **characterized** in that the underpressure is effected at least with an underpressure impulse, which is produced by means of the position and/or shape of a member, such as a foil, placed against or in the vicinity of the web (W).

13. Method according to claim 11 or 12, **characterized** in that the absorbency is increased with successive underpressure and over-pressure impulses.

14. Method according to any of the claims 11 to 13, **characterized** in that the liquid is added on the surface of the web to wet the web, whereafter the web is calendered.

15. Method according to any of the foregoing claims, **characterized** in that the absorbency of the surface is increased in a profiled manner in the transverse direction of the web (W), for example by profiling the effect of an energy treatment.

16. Method according to any of the foregoing claims, **characterized** in that the treatment is effected on the surface of the web in which the fibres are exposed or surface sized.

17. Apparatus for treating the surface of a web, which comprises a device (2) for adding liquid, located in the travel path of a paper or paperboard web (W) to bring liquid possibly with other constituents on the surface of the web, **characterized** in that in the travel direction of the web (W), before or concurrently with the device (2) for adding liquid, the apparatus comprises a device (1) for reducing web surface hydrophobicity, which is arranged to increase the absorbency of the surface of the web in the travel path of the web at a point where the web has already been formed and is at least partly dried.

18. Apparatus according to claim 17, **characterized** in that the device (1) is an energy treatment device, which is arranged to issue energy at least to the immediate vicinity of the surface of the web (W) in order to produce new polar groups on the surface of the web.

19. Apparatus according to claim 18, **characterized** in that the energy treatment device is a corona treatment device.

20. Apparatus according to claim 18, **characterized** in that the energy treatment device is a flame treatment device.

21. Apparatus according to claim 18, **characterized** in that the energy treatment device is an ozonization device.

22. Apparatus according to any of the claims 18 to 21, **characterized** in that the apparatus comprises at least two different types of devices (1) selected from the group consisting of a corona treatment device, a flame treatment device, and an ozonization device.

23. Apparatus according to claim 17, **characterized** in that the device (1) is a steaming device which is arranged to direct steam on the surface of the web (W).

24. Apparatus according to any of the claims 18 to 23, **characterized** in that the device (2) for adding liquid is a wetting device.

25. Apparatus according to claim 24, **characterized** in that the wetting device is a spray wetting device, a film transfer wetting device, a moistening device based on the adjustment of the relative humidity of air, or a steaming device.

26. Apparatus according to claims 23 and 25, **characterized** in that the device (1) is a steaming device, and the wetting device is a spray wetting device located underneath the web .

27. Apparatus according to any of the claims 18 to 23, **characterized** in that the device (2) for adding liquid is a coating device, such as a surface sizing device or a pigmenting device, which is arranged to add liquid on the surface of the web together with other constituents intended as a coating of the web.

28. Apparatus according to claim 17, **characterized** in that the device (1) is placed substantially at the same spot with the device (2) for adding liquid on the opposite side of the web (W) and it is arranged to effect at least an underpressure on the surface of the web (W).

29. Apparatus according to claim 28, **characterized** in that the device (1) comprises at least one member placed against or in the vicinity of the web (W), the position and /or shape of which member effects at least an underpressure impulse.

30. Apparatus according to claim 29, **characterized** in that the member effects an over-pressure and underpressure impulse one after the other.

31. Apparatus according to any of the claims 28 to 30, **characterized** in that the device (2) for adding liquid is a wetting device.

32. Apparatus according to claim 31, **characterized** in that the wetting device is a spray wetting device located underneath the web.

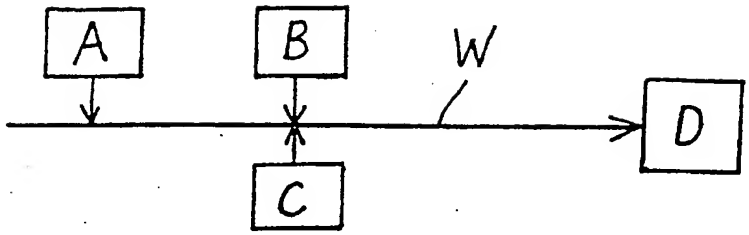


Fig. 1

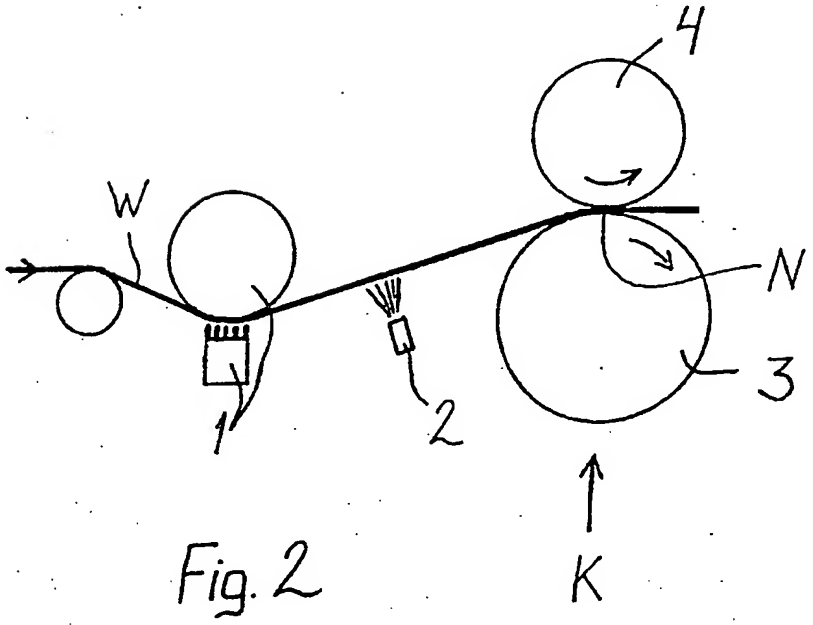


Fig. 2

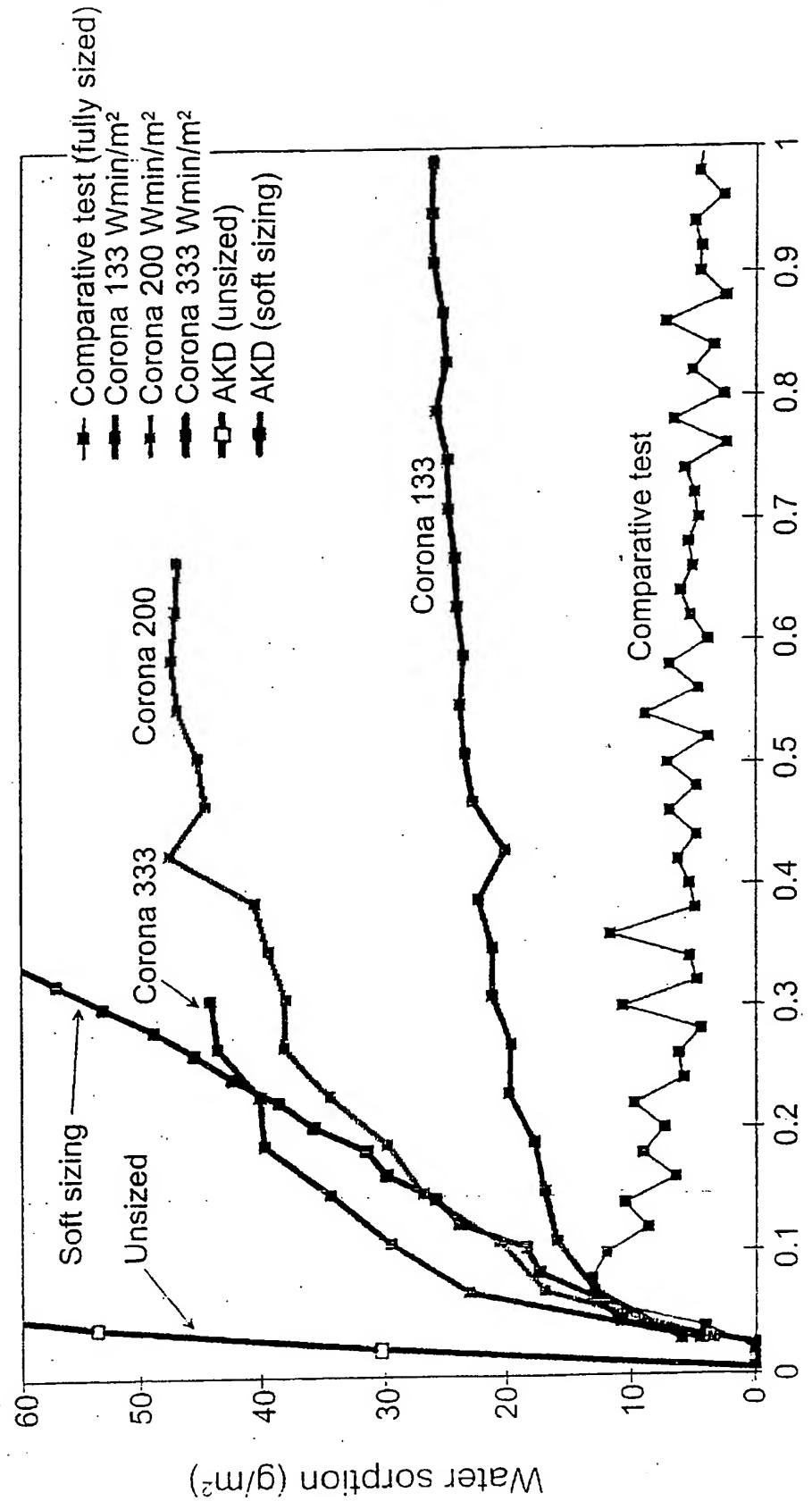
Comparative test (fully sized)
Corona 133 Wmin/m²
Corona 200 Wmin/m²
Corona 333 Wmin/m²
AKD (unsized)
AKD (soft sizing)
Soft sizing
Unsized
Corona 333
Corona 200
Corona 133
Comparative test
Water sorption (g/m²)
Contact time (s)
0
10
20
30
40
50
60
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

Fig. 3

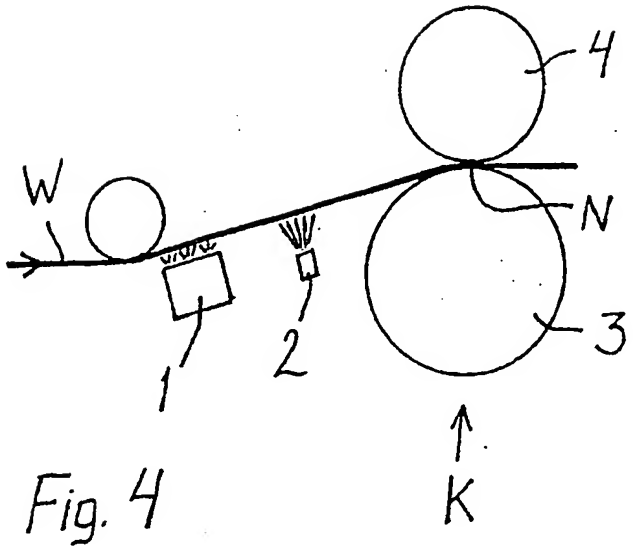


Fig. 4

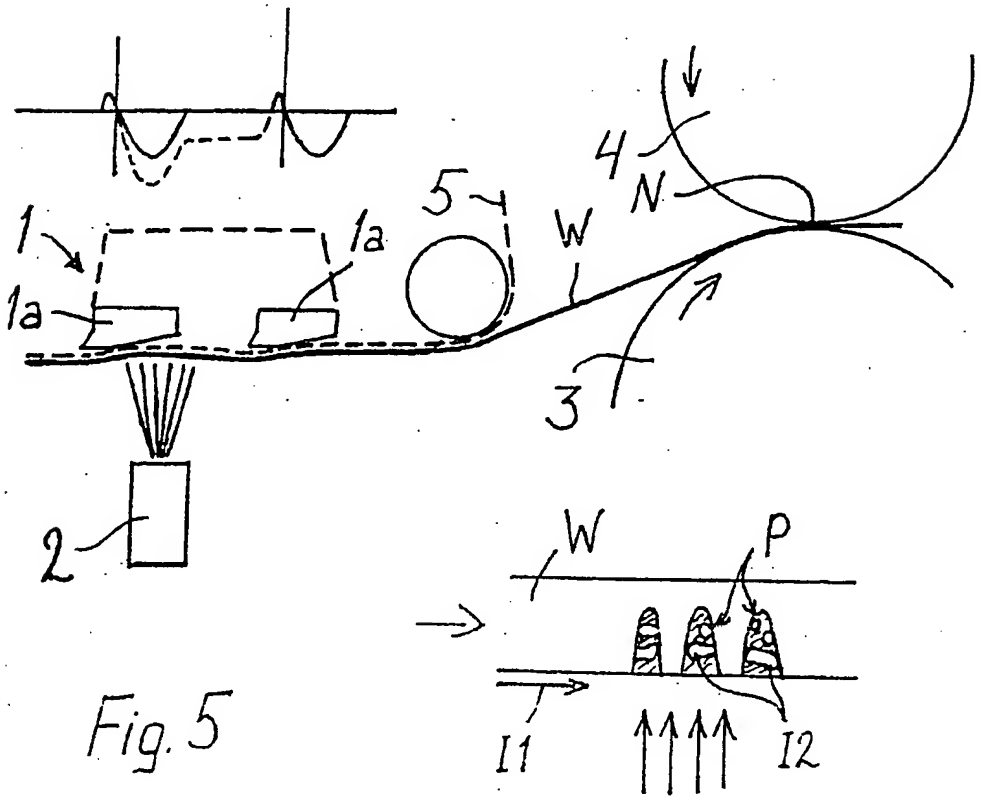


Fig. 5

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 99/00546

## A. CLASSIFICATION OF SUBJECT MATTER

IPC6: D21H 23/30, D21H 25/04
According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: B05D, D21G, D21H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | DE 3115958 A1 (KALWAR, KLAUS), 16 December 1982 (16.12.82), page 2; page 4, line 22 - line 24, claims 1 and 6, abstract<br>-- | 1-32 |
| X | DE 4324337 A1 (FAUSEL, THOMAS E.), 26 January 1995 (26.01.95), column 1, line 13 - line 23; column 3, line 67 - column 4, line 53, claims 1 and 13<br>-- | 1-32 |
| X | US 5619927 A (STEFAN WINHEIM), 15 April 1997 (15.04.97), column 1, line 45 - column 2, line 28; column 4, line 37 - column 5, line 19, claim 1<br>-- | 1-32 |

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 28 Sept 1999 | 30 -09- 1999 |
| Name and mailing address of the ISA/<br>Swedish Patent Office<br>Box 5055, S-102 42 STOCKHOLM<br>Facsimile No. + 46 8 666 02 86 | Authorized officer<br>Barbro Nilsson/Els<br>Telephone No. + 46 8 782 25 00 |

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI 99/00546

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | EP 0464775 A2 (FUJI PHOTO FILM CO., LTD.), 8 January 1992 (08.01.92), page 2, claim 1<br>--- | 1-32 |
| A | EP 0463213 A1 (JEAN HIEDEMANN GMBH & CO.KG), 2 January 1992 (02.01.92), claim 1<br>---<br>-------- | 1-32 |

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/FI 99/00546

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---|---|---|
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| DE 4324337 A1 | 26/01/95 | NONE | |
| US 5619927 A | 15/04/97 | DE 4431252 A | 07/03/96 |
| | | EP 0699529 A,B | 06/03/96 |
| | | SE 0699529 T3 | |
| | | US 5642671 A | 01/07/97 |
| EP 0464775 A2 | 08/01/92 | DE 69127775 D,T | 15/01/98 |
| | | JP 4065088 A | 02/03/92 |
| | | US 5138971 A | 18/08/92 |
| EP 0463213 A1 | 02/01/92 | NONE | |